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Beam Stability and Control in Solenoidal Transport Channels

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Recent studies [1,2] have identified an important mechanism of space-charge induced transport limits in periodic quadrupole focusing channels. It was found that as the applied focusing strength of the lattice increases beyond about 85 degrees per lattice period (measured by single particle phase advance) that resonant surfaces for halo particles closely approach the rms equivalent beam core. For a smooth initial distribution, this effect leads to strong halo with a significant fraction of particles rapidly evolving outside the rms core, with increased statistical emittance, particle losses, and degraded transport. With the increased interest in solenoidal transport for High Energy Density Physics applications, we explore the existence of analogous limits in solenoidal transport. It is found that the halo-induced transport limits are much weaker in high occupancy solenoid lattices. This is due to lower amplitude matched envelope flutter driving weaker halo resonances that remain farther outside the core. The parametric improvement of transport properties is verified using WARP simulations. Another important issue in solenoidal transport is steering the beam to correct for misalignment induced centroid oscillations. In solenoidal transport lattices these oscillations are complicated due to the Larmor precession of the orbit in the solenoidal field. A formulation is derived to describe the centroid oscillations and enable optimal corrections.

[1] S.M. Lund and S.R. Chawla, "Space-charge transport limits of ion beams in periodic quadrupole focusing channels," NIMA 561, 203-208 (2006)
[2] S.M. Lund, J.J. Barnard, B. Bukh, S.R. Chawla, and S.H. Chilton, "A core-particle model for periodically focused ion beams with intense space-charge," NIMA 577, 173-185 (2007)